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GLOBAL YOUNGER DRYAS?

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INTRODUCTION

Objectives of the Working Group

The existence of the Younger Dryas cold event has been known for over a century. First named and described from buried leaves and fruits of *Dryas octopetala* (Rosaceae family) in Scandinavia, the reappearance of these tundra indicators after shrubs and trees had begun to colonize a glaciated landscape (the Allerød warming), suggested a reversion to colder conditions (Jensen, 1938). Numerous stratigraphic studies subsequently proved the cooling as characteristic of late-glacial pollen diagrams throughout Europe 11–10,000 ^{14}C years BP (Iversen, 1954; Watts, 1980). While the magnitude, timing, and distribution of this event has had considerable attention in Europe itself since that time, it is only in the last two decades that the focus has expanded to include the the extra-European presence of the signal. We define the Younger Dryas here as a chronozone (Mangerud *et al.*, 1974), because it is only through the ^{14}C chronology that we may correlate vegetational and climatic events in various regions outside Europe. Unfortunately, a plateau may exist in the record at 10,000 ^{14}C years BP (Ammann and Lotter, 1989; Kromer and Becker, 1990), resulting in the same ^{14}C ages over a stratigraphic interval due to variations in the proportion of ^{14}C in the atmosphere. However, without tephra stratigraphy or other means of correlation we must rely on ^{14}C chronology, and all chronology referenced in this paper is in radiocarbon years BP. The aims of the Global Younger Dryas? Working Group include the following:

(1) To generate a critical assessment of the late-Pleistocene/Holocene transition pollen stratigraphy throughout various regions of the globe, excluding Europe, in order to determine whether or not a climatic reversal is present. This task is not an easy one for many reasons. Lack of close sampling intervals in many cores, lack of consistent regional pollen stratigraphies, and poor chronological control all contribute to the difficulty in addressing this question. Additionally, the palynologist faces the problem of translating a palynological change into vegetational change and then making a climatic interpretation. The participants of this working group (Table 1) have made a large effort to include all existing ^{14}C chronologies in regional reviews for the reader's benefit.

(2) To produce new late-glacial pollen and glacial records of change which have good chronological control, preferably using accelerator mass spectrometry (AMS) ^{14}C dating.

(3) To provide an interdisciplinary focus from comparison of ice core stratigraphy, marine records, and glacial and pollen stratigraphy so as to improve our understanding of the mechanism and origin of this event.

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Summary of Earlier Work

The late-glacial paleoecological history of the globe comprises a vast literature, which would be impossible to summarize in this review. Early reviews of Younger Dryas European pollen evidence (Watts, 1980) emphasized the dramatic changes in vegetation that characterized both coastal and inland areas. In areas outside Europe, few researchers correlated late-glacial fluctuations with the Allerød/Younger Dryas oscillation, but some exceptions exist, and are being investigated now with renewed interest. It was the discovery of a clear Younger Dryas (YD) signal in the Greenland ice cores in the last decade (Dansgaard *et al.*, 1989; Alley *et al.*, 1993; Taylor *et al.*, 1993) that sparked additional interest in the late-glacial climate. These high-resolution, multi-proxy records generated enhanced impetus to understand the cause of the dramatic shift in climate that characterized Greenland and Europe roughly 12,800–11,600 calendar years ago (ice-core chronology). The record of a YD methane signal in Antarctic ice cores (Chappellaz *et al.*, 1990) showed the extent of the geographic record of the changes which were characteristic of this climatic interval.

In contrast to the European evidence for the YD, most North American data prior to the late 1980s was interpreted as indicative of uniform warming after ice retreat (Watts, 1983, Gaudreau and Webb, 1985). An exception to this pattern was the pollen and glacial evidence noted in the Great Lakes region of North America, which was related to the YD (Saarnisto, 1974; Bjorck, 1984; Shane, 1987) and the lithological and pollen data from sites in Atlantic maritime Canada (Mott *et al.*, 1986).

Taking a more global view, Broecker *et al.* (1985) and Rind *et al.* (1986) summarized the palynological, marine, and glacial evidence that supported a possible global YD expression, and provided a hypothesis and a model concerning its origin related to changes in ocean circulation. They noted that researchers in northeastern maritime Canada, Pacific northwestern North America, northern South America, southern South America, Russia, China, and Africa all had suggested that the late-glacial oscillation they recorded might be correlative with the YD (Rind *et al.*, 1986).

The importance of understanding the Younger Dryas event in its geographic extent, magnitude, and marine–ice–terrestrial connection has led to the formation of this working group (Table 2). Publications of this working group to date are listed in Table 3, and the global summary of the YD includes this research. There is, of course, considerable overlap with all other IGCP-253 working groups. For example, IGCP-253 Working Group No. 4, North Atlantic Seaboard Programme, has produced a volume of papers (Lowe, 1994) that addresses the late-glacial history of many regions surrounding the North Atlantic. In contrast to earlier views suggesting that the Younger Dryas was strictly a European event (i.e. Mercer, 1969), this set of papers includes summary data from Iceland, Nova Scotia, New Brunswick, Newfoundland, Quebec, Baffin Island, northern Labrador, and southern New England. Most of these regions now report a YD oscillation, except Quebec. Additions to the European YD are new summaries from the eastern Mediterranean region, suggesting that the oscillation characterized some sites there (Rossignol-Strick, *in press*; Bottema, *in press*).

Prior to the last decade, reliance on conventional dating greatly limited the strength of YD correlation. The recent technological advance of improved chronological resolution and precision with the AMS ^{14}C-dating has resulted in a much stronger understanding of the timing of late-glacial events, and improved correlation with the European YD sites. The attempt to take an interdisciplinary view has also resulted in a much better appreciation of the complexity of the global climate system. Although many problems in correcting ^{14}C ages to calendar years remain (Bard *et al.*, 1993), it is clear that the potential to link the response of the terrestrial system to ocean and atmospheric changes has improved during the last decade.

TABLE 2. Global Younger Dryas? Working Group Activities: Meetings

- *September, 1992*
  Global Younger Dryas? Symposium, International Palynological Meeting, Aix-en-Provence, France (organized by D. Peteet, N. Khotinsky, R. Mathewes). 150 attendees, with 11 papers presented. Abstracts published in IPC Program and Abstracts, 1992.
- *December 1992*
  Fall American Geophysical Union Mtg, San Francisco, California, special Symposium entitled High Latitude Paleoclimate Change (D. Peteet and V. Markgraf, presiding). 100 attendees, with 14 paper presentations representing seven countries. The focus of the meeting was the comparison of late-glacial ice core, marine, and terrestrial high latitude pollen and glacial records. The YD was targeted as a major item of interest for each of the various indices in widespread regions, ranging from Greenland, high latitude North Atlantic and North Pacific regions to South America and Antarctica. Abstracts of papers are published in EOS.
- *April 1993*
  PAGES (Past Global Climate Changes) and Lamont Climate Center sponsored a small Global Younger Dryas? Workshop at LDGO. 20 attendees, with seven paper presentations representing three countries. A very small, interdisciplinary group of researchers working on ice cores, glacial records, marine cores, pollen records, and atmospheric processes. Aim of the meeting was to produce a 10-pg document stating the state-of-art knowledge concerning the subject, gaps in our understanding, and recommendations for future research. Published in EOS 74: 587-589.
- *June 1993*
  Global Younger Dryas? Symposium, Winnipeg, Manitoba 50 + attendees, with seven paper presentations representing five countries. Focus of the meeting was to present papers concerning the presence or absence of an event correlative with the European Younger Dryas 11–10,000 ^{14}C years BP, within the context of the late-glacial interval. Abstracts published by J. Teller, Winnipeg, 1993.

TABLE 3. Publications: IGCP Global Younger Dryas?

8th Int. Palynological Congress Programs and Abstracts, 6–12 Sept. 1992

Peteet, D. (ed.) (1993). Alley, R., Bond, G., Chappellaz, J., Clapperton, C., Del Genio, A., Keigwin, L. and Peteet, D. (1993). Global Younger Dryas?, *EOS*, **74** (50), 587–589.

Peteet, D. (ed.) (1993). Global Younger Dryas?, *Quaternary Sci. Rev.*, **12**, p.v, and list of papers

Ammann, B., Birks, H.J.B., Drescher-Schneider, R., Juggins, S., Lang, G. and Lotter, A.F. (1993). Patterns of variation in late-glacial pollen stratigraphy along a Northwest–Southeast Transect Through Switzerland — a Numerical Analysis. *Quaternary Sci. Rev.*, **12**, 277–286.

Goslar, T., Kuc, T., Ralska-Jasiewiczowa, Rozanski, K., Arnold, M., Bard, E., van Geel, B., Pazdur, M.F., Szeroczynska, K., Wicik, B., Wieckowski, K. and Walanus, A. (1993). High-resolution lacustrine record of the late-glacial/Holocene transition in Central Europe. *Quaternary Sci. Rev.*, **12**, 287–294.

Mayle, F.E., Levesque, A.J. and Cwynar, L.C. (1993). Alnus as an indicator taxon of the Younger Dryas cooling in eastern North America. *Quaternary Sci. Rev.*, **12**, 295–306.

Shane, L.C.K. and Anderson, K.H. (1993). Intensity, gradients, and reversals in late glacial environmental change in east-central North America. *Quaternary Sci. Rev.*, **12**, 307–320.

Mathewes, R.W. (1993). Evidence for Younger Dryas-Age Cooling on the North Pacific coast of America. *Quaternary Sci. Rev.*, **12**, 321–332.

Kuhry, P., Hooghiemstra, H., Van Geel, B. and Van der Hammen, T. (1993). The El Abra stadial in the eastern Cordillera of Colombia (South America). *Quaternary Sci. Rev.*, **12**, 333–344.

Heusser, C.J. (1993). Late-glacial of Southern South America. *Quaternary Sci. Rev.*, **12**, 345–350.

Markgraf, V. (1993). Younger Dryas in southernmost South America. *Quaternary Sci. Rev.*, **21**, 346–351.

Peteet, D.M., Vogel, J.S., Nelson, D.E., Southon, J.R., Nickmann, R.J., and Heusser, L.E. (1990). Younger Dryas climatic reversal in northeastern USA? AMS ages for an old problem. *Quaternary Res.*, **33**, 219–230.

Peteet, D.M., Daniels, R., Heusser, L.E., Vogel, J.S., Southon, J.R. and Nelson, D.E. (1994). Wisconsinan late-glacial environmental change in southern New England: a regional synthesis. *J. Quaternary Sci.*, **9** (2), 151–154.

EVIDENCE FOR EXTRA-EUROPEAN YOUNGER DRYAS

North America

Recent attention to the late-glacial has resulted in the emerging re-examination of whether or not the YD is evident in various regions of North America. This summary of regional evidence focuses primarily on regions adjacent to the existing ice sheets, spanning the continent. While we focus on areas where this oscillation has been identified, other marginal ice sheet areas exist where the oscillation has not been recognized, i.e. Maine and Quebec.

Eastern Canada

At the eastern margin of the Laurentide ice sheet, numerous late-glacial buried sequences, found more than half a century ago, indicate a sudden oscillation in climate (Mott, 1985; Mott *et al.*, 1986). For many years problems with conventional ^{14}C-dating precluded their precise correlation with the YD event, but the advent of AMS dating combined with very detailed macrofossil analysis has resulted in the strongest establishment of this correlation in North America (Fig. 1). Colder climatic conditions resulted in the replacement of shrub-tundra (*Betula glandulosa*) with herb tundra (Cyperaceae, *Artemisia, Oxyria*) in central New Brunswick and northern Nova Scotia during the YD (Levesque *et al.*, 1993; Mayle *et al.*, 1993a,b; Mott, 1994).

In southern New Brunswick and central mainland Nova Scotia, closed forest (*Picea*) was replaced by shrub tundra (*Alnus crispa*, Cyperaceae, Poaceae) (Mayle *et al.*, 1993a,b; Cwynar *et al.*, 1994; Levesque *et al.*, 1994; Mott, 1994; Mayle and Cwynar, *in press*). The lake sediments are characterized by increased inorganic material from landscape erosion. In New Brunswick, diatom production was greatly diminished (Rawlence, 1988), and surface water temperature reconstructions derived from modern chironomid/temperature relationships indicate temperature declines of 6–7°C (Walker *et al.*, 1991; Wilson *et al.*, 1993) and at Pine Ridge Pond, New Brunswick, a decline of 12°C (Levesque *et al.*, 1994). In Newfoundland, accelerated erosion of surface soils is indicated by an increase in alkali in the sediment, and palynological data from eight sites show YD increases in various herb tundra species, e.g.

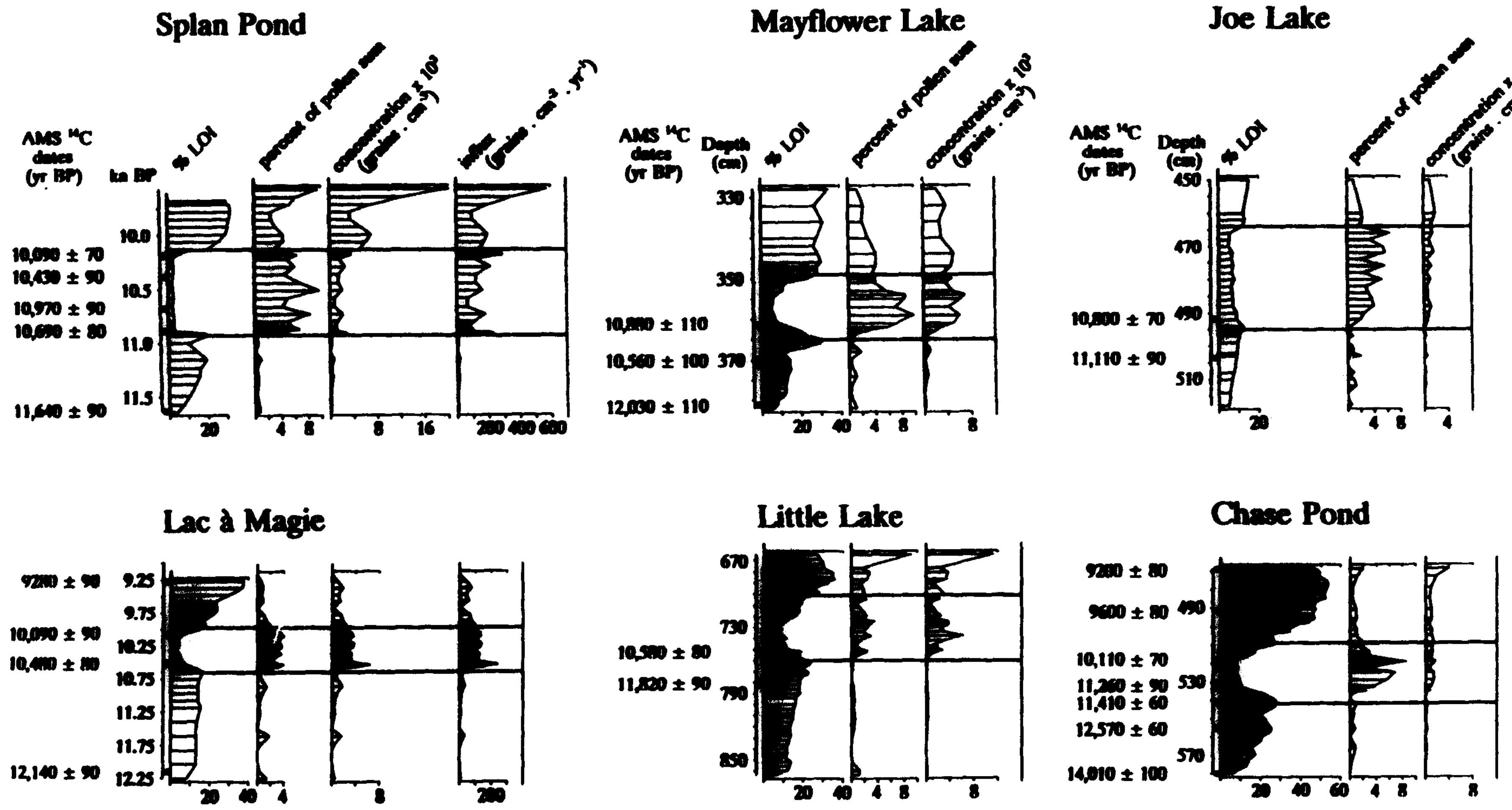

FIG. 1. Changes in percentage, concentration, and influx values for *Alnus crispa* pollen during the late-glacial and early Holocene in maritime Canada. The continuous horizontal lines mark the boundaries of the Younger Dryas as determined from changes in percent LOI (From Mayle *et al.*, 1993).

Ericales and Cyperaceae (Anderson and MacPherson, 1994).

In contrast to this pattern of coastal Canadian response to the Younger Dryas cooling, palynological records from Quebec do not appear to record a significant signal (Richard, 1994) during the YD, but a cold episode in the Holocene is noted at 9.5 ^{14}C years BP.

Southern New England

Southern New England shows a strong regional pattern of late-glacial palynological change (Peteet, 1987), that is apparent in over twenty lake records and has been recognized since the 1950s (Leopold, 1956). However, since that time the changes have been interpreted as indicating unidirectional warming (e.g. Davis, 1967; Watts, 1983; Gaudreau and Webb, 1985). Whether or not this palynological change represented a regional vegetational change was debated for many years, which precluded its definition as a YD correlative. Macrofossil analysis and pollen influx from three of these lakes have resulted in the documentation of the presence of temperate species in southern New England prior to the YD cooling, while ^{14}C AMS dates provide a chronology for the timing of the YD response (Peteet *et al.*, 1990, 1993, 1994). Regionally, organic sedimentation began abruptly approximately 12,400 years BP, when the ice had retreated enough for the lake basins to form. Fluctuations in a mixed coniferious-deciduous forest (*Picea, Abies, Larix, Pinus strobus, Quercus, Fraxinus*) culminate about 11,000 years BP with a rapid disappearance of the thermophilous trees and a marked increase in the boreal indicators (*Picea, Abies, Larix, Betula papyrifera, Alnus*) as climate cooled (Fig. 2). This palynological signal is supported by dominance of the boreal macrofossils and the disappearance of *Pinus strobus* needles. We infer this vegetational change to be indicative of an approximate July cooling of 3–4°C (Peteet *et al.*, 1990, 1993). The sharp return to warmer conditions at 10,000 ^{14}C BP was marked by the dominance of *Pinus strobus* and loss of the boreal component.

Close-interval analyses of a pollen and macrofossil late-glacial record from the Hudson Highlands of

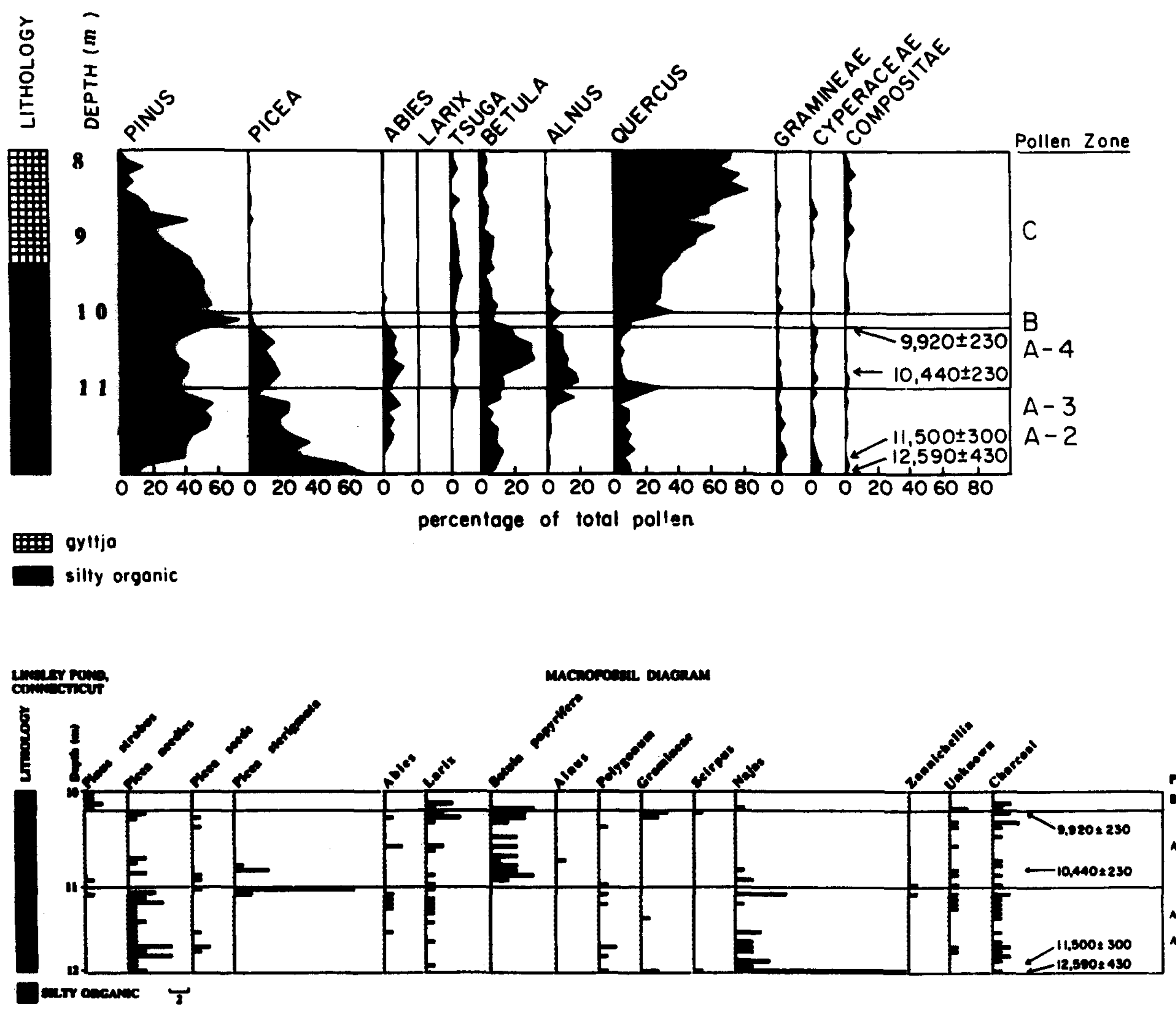

FIG. 2. Pollen percentage diagram of selected types, 8–12 m depth, Linsley Pond, Conn. (top). Macrofossil diagram from 10 to 12 m depth, Linsley Pond, Conn. Samples represent material from 50 cms of sediment at 5 cm intervals. *Pinus strobus*, *Abies*, and *Larix* macrofossils are needles, *Betula papyrifera* remains include cone scales and seeds, and the remainder denote seeds or fruits (bottom) (from Peteet *et al.*, 1993).

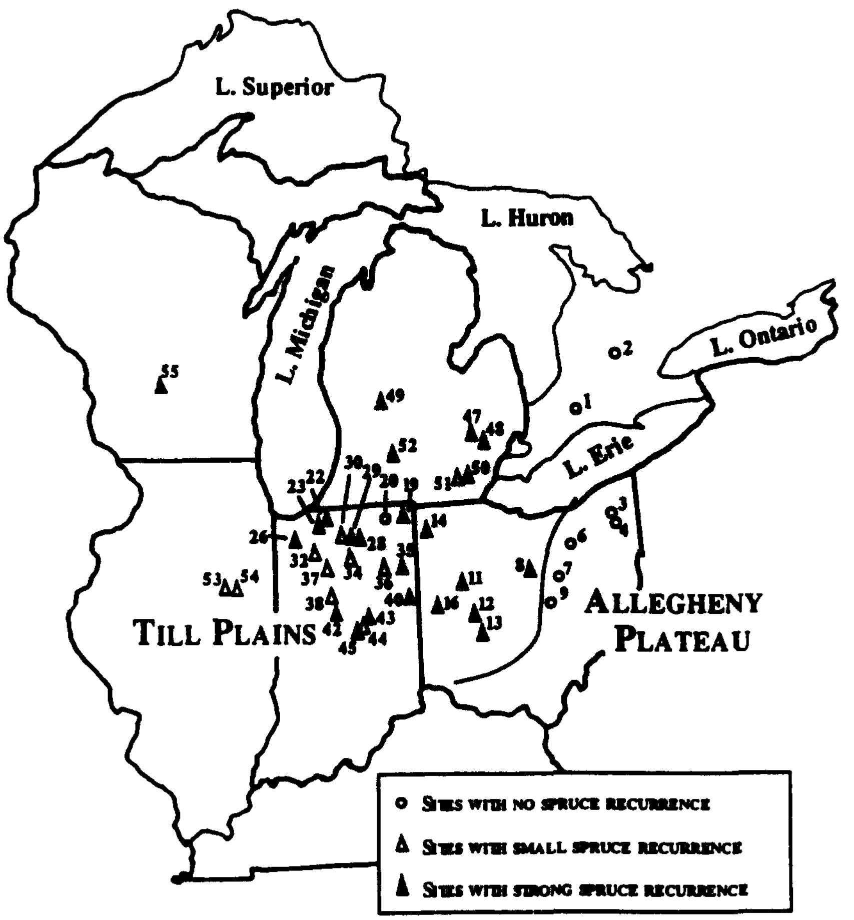

FIG. 3. Map showing intensity gradient in the *Picea* recurrence. Only sites with interpretable records are included. Numbers correspond to Table 1 in Shane *et al.* (1993). Open circles are sites with no *Picea* fluctuation in the pollen record; closed triangles are sites with a strong *Picea* pollen fluctuation (increase from a low point of over ca. 7%); open triangles are sites with a minor *Picea* pollen fluctuation (from Shane and Anderson, 1993).

southeastern New York provide an additional record of YD cooling with a dominance of *Abies* and *Alnus* 11–10,000 years BP (Maenza-Gmelch, 1994). These results contrast with the apparent lack of a YD signal in northern New England, where no climatic oscillation has been identified (Jacobson *et al.*, 1987).

Midwestern U.S.A.

From scrutiny of more than 25 conventional radiocarbon-dated pollen sites in the Allegheny Plateau (east) and Till Plains (west) of the Great Lakes region, Shane (1987) and Shane and Anderson (1993) have noted a cold oscillation equivalent to the YD in the western region. This cooling is defined by the rapid recurrence of *Picea* at the close of the late-glacial in the Till Plains sites (Fig. 3). Transfer function estimates show a January temperature drop of –5 to –2°C and a July temperature drop of 1–2°C, with a precipitation increase from the Allerød. Whether or not the climate reversal represents a direct result of glacial and meltwater changes in the Great Lakes region or is due to extra-regional forcing is not yet resolved (Shane and Anderson, 1993). Future attention to AMS dating is needed to refine the chronology.

Pacific Northwest Coast

The Pacific Northwest record of palynological change from the Olympic Peninsula northwestward to coastal Alaska exhibits climatic oscillations during the late-glacial (Heusser, 1960). Increases in *Tsuga mertensiana* are the most notable link in more than ten sites to a Younger Dryas cooling along the British Columbia coastline (Mathewes, 1973; Hebda, 1983; Mathewes, 1993). The pollen percentage increase is small (3–5%), but mountain hemlock is notable for its very low pollen production, and a percentage increase is interpreted as a definite forest change (Fig. 4). This late-glacial increase from many sites suggests a decline in temperature and increased moisture in comparison with preceding centuries. AMS studies in progress will further constrain the timing of this oscillation.

To the north, one site in Glacier Bay, southeastern Alaska, shows an expansion of tundra elements concurrent with increased inorganic sediments between 10,600 and 9990 years BP and has thus been interpreted as a possible YD oscillation (Engstrom *et al.*, 1990).

Northwestward, a suite of coastal sections from Kodiak Island exhibits an abrupt lithological oscillation from 10,800 to 10,000 AMS ^{14}C years BP (Peteet

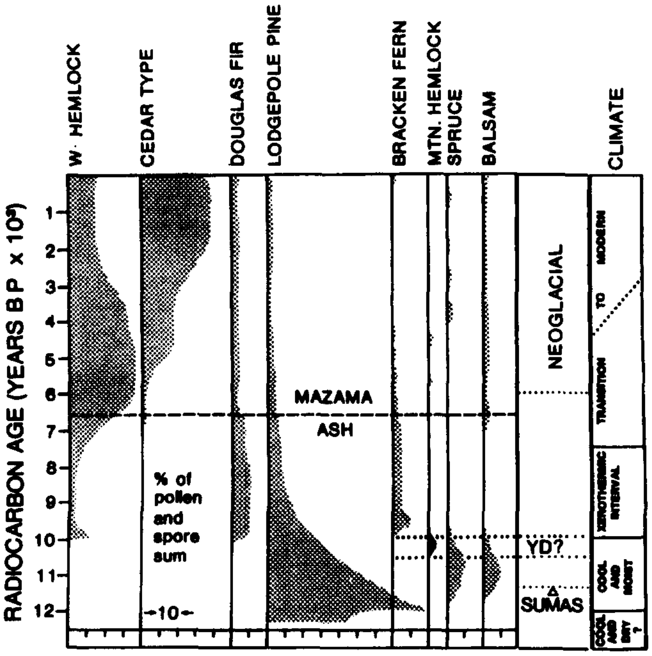

FIG. 4. Generalized pollen diagram for Marion Lake, British Columbia, with climate interpretation and geologic-climate units of southwestern BC that are associated with cooling. YD = Younger Dryas chronozone (11–10 ka BP) with high mountain hemlock (*Tsuga mertensiana*) pollen; Sumas = climax of Sumas Stade ice readvance into Fraser Lowland around 11.3 ka BP (from Mathewes, 1993).

and Mann, 1994). Palynological and macrofossil data completed from one site support the change as a rapid and dramatic cooling, with loss of Polypodiaceae and dominance of *Empetrum* and *Artemisia*. The return to warm conditions at 10,000 ^{14}C years BP is very abrupt.

The pattern, magnitude, and precise timing of these vegetational and climatic changes throughout North America deserves additional attention. Problems with radiocarbon plateaus at 12,700 and 10,000 ^{14}C years BP during the late-glacial to postglacial transition (Ammann and Lotter, 1989; Kromer and Becker, 1990) complicate the estimation of rates of change. Many questions remain as to the geographic extent of the cooling and why significant gaps appear to exist (i.e. Quebec, northern New England). The extent of the oscillation as one moves southward is also an important question, as references have been made to its possible occurrence in Kentucky (Wilkins *et al.*, 1991). Comparison of the terrestrial data with ice core and marine records indicates the importance of consideration of migration lags, thresholds, and separation of temperature and moisture signals. Evidence of a possible North Pacific YD equivalent suggests that the origin of the terrestrial cooling may not have been restricted to the North Atlantic, or that the atmospheric response was very rapid and widespread (Peteet, 1993a,b).

Central America

Leyden (*in press*) has summarized late-glacial evidence from several wetlands in Central America. Two of these records, La Chonta bog area, Costa Rica (Hooghiemstra *et al.*, 1992) and Lake Quexil, Guatemala (Deevey *et al.*, 1983; Leyden, 1984; Leyden *et al.*, 1993) exhibit late-glacial reversals, estimated to have begun 12–11,000 years BP and ending before 10,300 years BP, but dating is not precise enough to establish a YD correlative event. Lake La Yeguada (Piperno *et al.*, 1990; Bush *et al.*, 1992) from lowland Panama, in contrast, does not show a clear late-glacial reversal.

South America

Colombia

In 1959, Van der Hammen and Gonzalez published a record of late-glacial climatic reversal in Colombian montane cores of the Eastern Cordillera. They named the warming the Guantiva interstadial, which was closely followed by the El Abra stadial (colder), and then the Holocene. Continued investigation of many sites (e.g. Fig. 5) by a variety of authors has shown this to be a regional palynological reversal (see Kuhry *et al.*, 1993), occurring approximately 11–10,000 ^{14}C years BP, correlative with the Allerod-Younger Dryas oscillation (Kuhry *et al.*, 1993; Van der Hammen and Hooghiemstra, *in press*). Colder climatic conditions during the El Abra stadial caused a 600 m lowering of the upper Andean forest limit and a cooling of 4°C compared to the present. Available conventional dating shows the transition from the Guantiva interstadial to the El Abra stadial to be 11,210 ± 90 and 10,820 ± 60, and warming may have started shortly after 10,380 ± 90 (Kuhry *et al.*, 1993). AMS dating is presently in progress to establish more closely the timing of the event (Van der Hammen and Hooghiemstra, *in press*).

In the Sierra Nevada del Cocuy, a glacial advance correlative with the El Abra stadial was named the Bocatoma stade (Gonzalez *et al.*, 1965). The ELA lowering was about 700 m.

In contrast to the correlation of the Colombian pollen and glacial stratigraphy with the YD event, Heine (1993) suggests that the evidence for a YD oscillation is as yet inconclusive, and that more dating is needed to establish this event in the tropical Andes.

Ecuador and Peru

According to a review by Hansen (*in press*) of the published palynological records that exist from Ecuador, none exhibit a late-glacial oscillation and all lack radiocarbon dating delineating the YD. In Peru, pollen data from four sites suggest one and possibly two late-glacial climatic oscillations but only one site, Laguna Junin, has dates which bracket the short-term climate change, and it appears to be between 12 and 11,000 years BP. No AMS dates are as yet available.

Chile and Argentina

Whether or not a late-glacial climatic reversal characterized southernmost South America has been

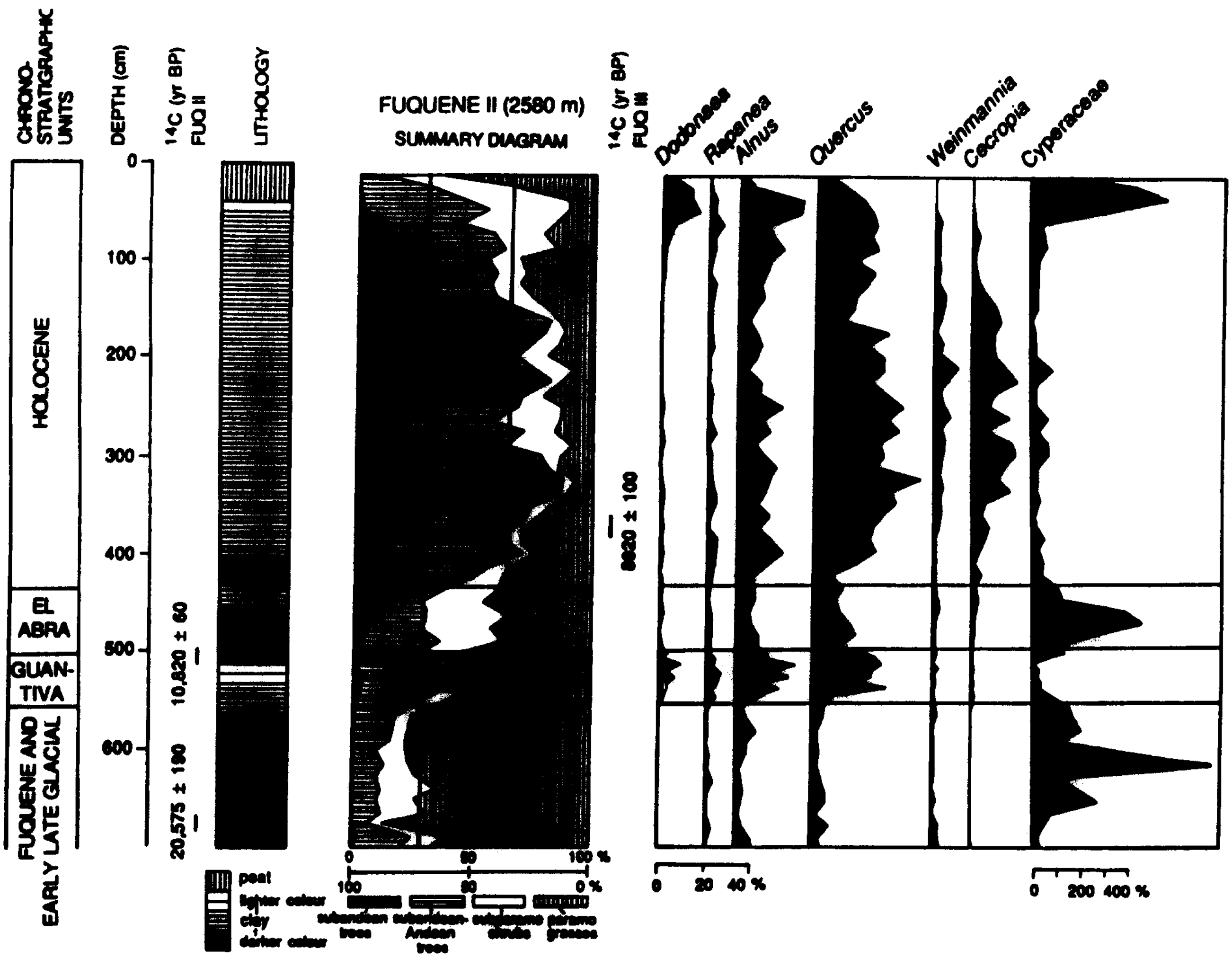

FIG. 5. Simplified pollen diagram from the upper part of the Laguna de Fuquene II core (Van Geel and Van der Hammen, 1973). Additional radiocarbon date from the Laguna de Fuquene III core (From Kuhry *et al.*, 1993).

controversial for almost a decade. Two recent reviews present both sides of the argument (Heusser, 1993; Markgraf 1993). While some records clearly do show an oscillation between about 11 and 10,000 years ago, such as Alerce and Rucanancu (Heusser, 1989, 1993), others such as Rio Caunahue (Heusser, 1981; Markgraf, 1991) do not. Markgraf (1993) ascribes some of the late-glacial variability in the records to the effects of fire. No AMS dates are available as yet to refine the chronologies.

Potential Glacial YD Evidence — the Americas

Osborne *et al.* (*in press*) present the late-glacial alpine evidence for a possible Younger Dryas equivalent. The best examples are in the Canadian (Crowfoot moraine; Osborne *et al.*, *in press*) and American Rockies (Triple Lakes, Colorado; Davis and Osborne, 1987), the Ecuadorian (Reschreiter moraine; Clapperton, 1990), Peruvian (Cordillera Oriental and Cordillera Blanca; Rodbell, 1991, 1993), and Bolivian Andes, and the Patagonian ice cap. Most are not dated well enough to correlate with the YD, but two readvances fall within the YD interval: an advance of the Crowfoot Glacier in Canada, and the Reschreiter Glacier in Ecuador. Heine (1993) suggests alternative explanations for the glacial chronologies from Ecuador.

Equatorial and East Africa

Coetzee (1967) suggested that a late-glacial palynological oscillation from Mt Kenya was related to moisture. New data from Burundi, equatorial Arica (Bonnefille *et al.*, *in press*) with AMS dates suggest that a vegetational oscillation did characterize the late-glacial. However, additional AMS-dated sites are needed to establish a regional climatic oscillation and to correlate with a YD signal.

South Africa

Scott *et al.* (*in press*) review the late-glacial evidence for a climatic oscillation in South Africa. From a total of 15 sites, they find that less than half have adequate resolution or dating to determine whether or not an oscillation exists. None of the palynological sequences in the interior so far suggest a Younger Dryas equivalent.

South East Asia

Maloney (*in press*) reviews the available evidence from Southeast Asia concerning the late-glacial. He notes that the clearest evidence for a possible climatic oscillation is found in west Java and north Sumatra, but both sites need better dating.

New Zealand

The available late-glacial pollen evidence for New Zealand, summarized by McGlone (*in press*), suggests that no significant reversal of the trend towards afforestation occurred after glaciation. However, many of the sites have poor sampling and chronological resolution. In contrast to the lack of palynological evidence for a YD in New Zealand, Denton and Hendy (1994) recently demonstrated a glacial advance of the Franz Josef Glacier to be a YD correlative.

SUMMARY AND FUTURE RESEARCH

A summary map of the global palynological evidence for the YD is presented in Fig. 6. One of the major contributions of this working group has been to establish the clear evidence for the YD outside Europe, in eastern North America. It is quite evident from the macrofossil evidence and the AMS ^{14}C-dating that vegetation responds very quickly to climatic change, both at the onset and the close of the YD. The probable extent of the YD in the midwestern U.S.A. and along the North Pacific coast is indicated by a playnological oscillation at many sites, but they are not characterized by firm chronology. The possible occurrences in Glacier Bay, Alaska, and Kodiak, Alaska await further palynological investigations.

The most convincing evidence outside North America is from Colombia, South America, where many sites show an oscillation but await clear AMS ^{14}C dating. Controversial regions where some sites seem to have an oscillation and others do not are Central America, southern South America, and the eastern Mediterranean region. A clear absence of a YD signal is not yet confirmed in any area, because high-resolution AMS-dated sites are rare, and none have been cited to prove that an oscillation is lacking during this interval. Regions where existing data suggest that no palynological oscillation took place include Ecuador and Peru, South Africa, and New Zealand, but in some of these same areas (New Zealand, possibly Peru) glacial advances do indicate a YD correlative.

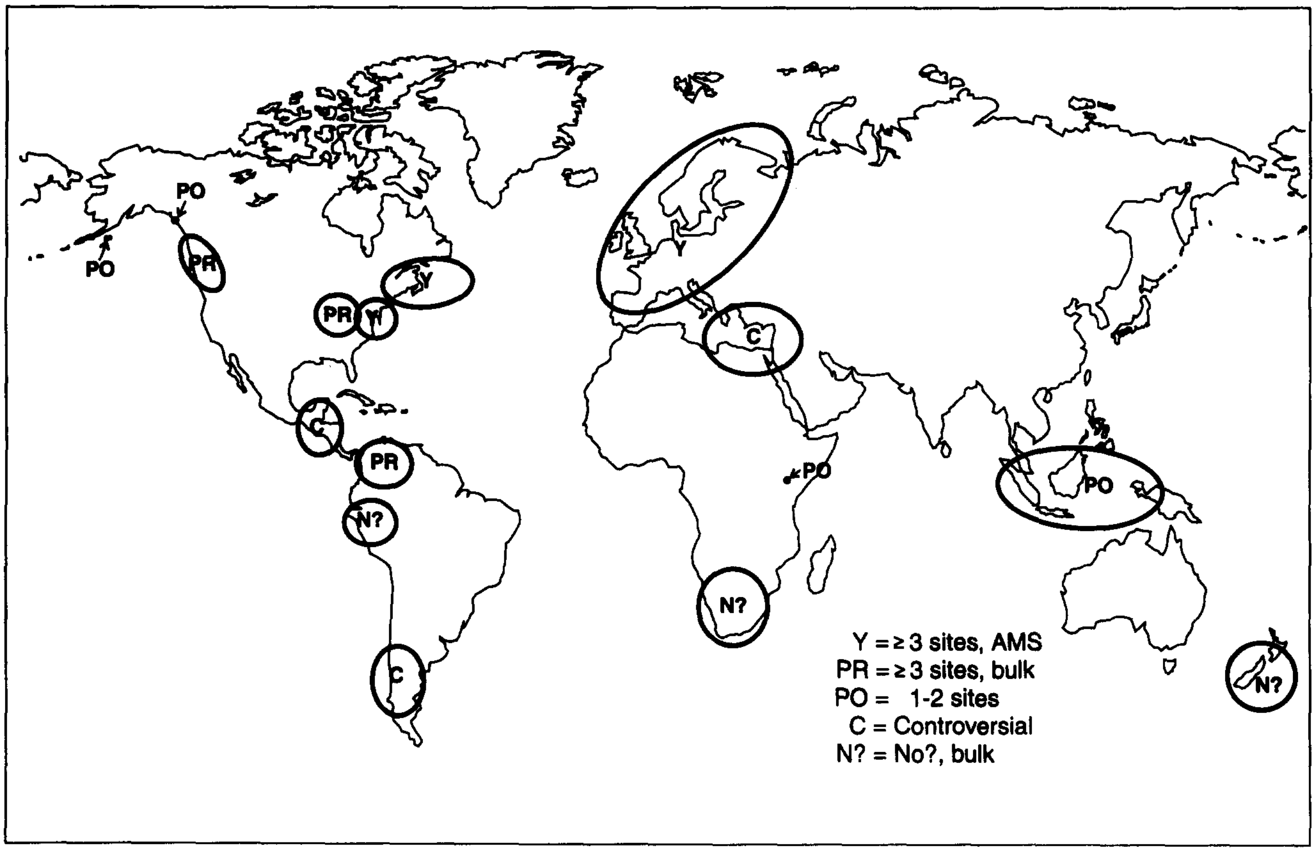

FIG. 6. Global map of distribution of palynological evidence for the Younger Dryas cooling 11–10,000 yr BP. Where clear palynological evidence exists for a climatic oscillation in three or more sites, with AMS ^{14}C dating, Y denotes a Yes YD (e.g. maritime eastern Canada). For regions where three or more sites show a palynological oscillation, but it is not yet AMS-dated, a PR is designated for Probable YD (i.e. Colombia). For sites where one or two oscillations exist, a PO denotes Possible YD (e.g. southern Alaska). For sites where some sites show an oscillation and others do not, a C denotes Controversial. Finally, where evidence for a YD is lacking, a N? is given for No? YD, unless three or more AMS sites have been investigated, in which case the designation would be N for No YD.

Examination of Fig. 6 reveals large areas of the continents where no designation for a YD can be made. Some of these continental areas were ice-covered during the YD (e.g. large portions of Canada) but in other regions lack of investigation or translation of literature into English (the former USSR) makes the areas difficult to assess. In particular, little appears to be known of India, Africa, large areas of S. America, and China. It is our hope that renewed interest in the YD will stimulate further pollen stratigraphic investigations in these regions in the future.

Through high-resolution sampling and dating in many regions of the globe, we eventually hope to be in a position to state with confidence whether or not the YD was a global event, and whether or not there were leads and lags in the expression of both vegetational and climatic change. By focused attention to interpretation of vegetational records, we hope to refine our estimates of temperature or moisture change. Careful analysis of the timing of the YD event in ice core, marine, and terrestrial records will help to expand the pattern of its geographic expression, and ultimately, may help us understand the mechanism of this dramatic climatic change.

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APPENDIX: PAPERS FOR NEXT GLOBAL YOUNGER DRYAS? EDITION OF *QUATERNARY SCIENCE REVIEWS*

Bonnefille, R., Riollet, G., Buchet, G., Arnold, M., Icole, M. and Lafont, R. Rusaka, a High Resolution Pollen Record for the Glacial/Interglacial Transition in Equatorial Africa.

Bottema, S. The Younger Dryas in the eastern Mediterranean.

Leyden, B.W. Evidence of the Younger Dryas in Central America.

Hansen, B.C.S. A review of late-glacial pollen records from Ecuador and Peru with reference to the Younger Dryas event.

Maloney, B.K. Evidence for the Younger Dryas event in Southeast Asia.

Mayle, F.E. and Cwynar, L.C. A review of multi-proxy data for the Younger Dryas in maritime eastern Canada.

McGlone, M.S. Landscape and vegetation change during the Younger Dryas interval in New Zealand.

Osborne, G., Clapperton, C., Davis, P.T., Reasoner, M., Rodbell, D.T., Seltzer, G.O., and Zielinski, G. Potential glacial evidence for the Younger Dryas event in the cordillera of North and South America.

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